

With the Author's Compliment

(5)

VOLKMANN'S CONTRACTURE

BY

LEONARD S. DUDGEON, M.R.C.S. ENG.,
M.R.C.P. LOND.

ASSISTANT IN THE ELECTRICAL DEPARTMENT, ST. THOMAS'S HOSPITAL.

Reprinted from THE LANCET, January 11, 1902



VOLKMANN'S CONTRACTURE.

THIS deformity, which was first described by Professor Richard Volkmann¹ in 1875, has since received little attention from the medical profession in this country. There is little to be found on the subject in books on surgery (either past or present) or on deformities, or, in fact, anywhere in the literature, except in a few scattered papers of which those by Page, Littlewood, and Barnard are the best; full reference will be given to these papers later. This form of contracture is said to be rare. This statement, I think, is incorrect; it is far more probable that it is only rare in the sense that there is a scarcity of literature on the subject. I have considered it best to give first the four cases which have come under my own notice and which are recorded here for the first time; secondly, to give a summary of all the cases in the literature as far as it has been possible to do so; and, finally, to discuss the deformity at length.

CASE 1.—The patient, a child, aged five years, was admitted into St. Thomas's Hospital under the care of Mr. H. H. Clutton on Sept. 15th, 1897. At Christmas, 1896, she had fallen downstairs and had broken her right arm just above the elbow-joint. She was taken at once to a medical man, by whom the fracture was set and the arm was put up in splints. According to the relatives there was no trace of a wound when the arm was first seen. Two days later they called in another medical man who took the splints off and found that there was a considerable wound over the seat of the fracture and a great deal of inflammation present, while the fingers were swollen and discoloured. The arm was dressed but the splints were not reapplied. Wasting and contracture seem to have set in during the process of healing, which appears to have been very slow and not finally completed until about six months after the original accident. On admission into St. Thomas's Hospital the condition was noted as follows: "The whole right arm is wasted, the forearm especially, consisting of little more than skin and bone. It is held pronated midway between pronation and supination and slightly flexed on the arm. The hand is flexed at right angles to the forearm; the fingers and thumb are slightly flexed on the palm. Extending right across the elbow-joint is a large scar which has produced considerable contraction in the surrounding skin. At the inner end of

this sear begins an abnormal bony prominence on the inner edge of the humerus, half an inch above the front of the internal condyle which appears to be in the normal position. A sharp ridge runs upwards from this bony point which is just beneath the skin. Complete flexion of the forearm is prevented by this bony prominence. Movements of pronation and supination cannot be performed actively and only to a slight extent passively. The head of the radius appears to be in the normal position, likewise the head of the ulna. The hand cannot be moved voluntarily. The interossei act fairly well. The fingers are flexed on the palm. Sensation of hand and forearm is normal; the hand cannot be extended." Dr. H. G. Turney, physician to the electrical department, reported that the electrical reactions were

FIG. 1.



Showing condition of hand and forearm in Case 1 on Nov. 22nd, 1901

normal. The diagnosis of ischaemic myositis was made. The treatment adopted was massage twice daily. On Oct. 15th the following note was made: "There is some improvement of the movement of the fingers, otherwise the condition practically remains unchanged, despite the massage twice daily." The patient left the hospital on Oct. 25th, 1897. On Nov. 22nd, 1901, the child was brought up to St. Thomas's Hospital at my request (Fig. 1). The forearm was extremely wasted, more so if possible than before, except at the upper end of the forearm, where the muscles were more bulky and firm and hard. The forearm, which was strongly pronated, was considerably shorter than its fellow, and the bones—i.e., the radius and the ulna—were much smaller in every way. The hand was flexed and could not be extended, neither could pronation or supination be performed, while the fingers were more pliable than they usually are

in such cases, being able to perform all movements to a certain extent. The inter-phalangeal joints were flexed, but on full flexion of the wrist they could be completely extended. The hand was cold and blue, but sensation was absolutely normal. There were no trophic changes of the skin or nails, &c. The finger-joints were quite normal. There was a well-marked prominent boss at the back of the wrist-joint. There was a large sear at the upper part of the forearm, showing the site of a past extensive pressure sore. All movements of the elbow-joint were perfect. Electrical reactions to both nerves and muscles were normal; it was surprising to see such atrophied muscles contract so sharply and so strongly. Both Mr. Clutton and Dr. Turney who saw the patient considered the case to be the worst one that they had ever seen. When the child left St. Thomas's Hospital in 1897 the parents were told to try massage. When I inquired of the child's father to what extent he had carried out the instructions his answer was: "As I found no improvement after three weeks' massage I gave it up as useless." I think that I can therefore state that the patient received practically no treatment, hence this disastrous result.

CASE 2.—The patient, a man, aged 20 years, was admitted under the care of Mr. Bernard Pitts into St. Thomas's Hospital on April 13th, 1898. He gave the following history. On June 18th, 1897, he sustained an injury to his forearm by means of a sledge-hammer; he was seen by two medical men at the time of the accident and five weeks later in the out-patient department at a "general hospital." The diagnosis of the injury was different in each case—(1) bad sprain, (2) dislocation of the wrist, and (3) fracture of the lower end of the radius and ulna. The practitioner who attended him at the time of his accident bandaged the forearm and hand on an anterior splint which reached the tip of the fingers. There was a good deal of swelling when the splint was applied. There was no discolouration of the fingers and only slight pain occurred. Five weeks later he went to the hospital. The splint was removed, there was no contracture now, and the arm was put in plaster for more than two months. (It will be noticed that contraction would be impossible if the splint reached to the tips of the fingers, but that it occurred as soon as the plaster splint was applied, as this reached only to the wrist-joint.) At the end of that time massage was applied and passive movements were practised. Contraction of the fingers on the palm of the hand was well marked two months after the accident. As an operation was advised at the hospital he left that institution and came to St. Thomas's Hospital. The left arm was now much wasted and the patient held the wrist flexed and likewise the fingers; all movements were considerably diminished. There was no sear on the forearm or hand which might show the site of a past pressure sore. There was no report on the electrical reactions. The treatment adopted was massage and faradic current daily. The patient left the hospital on April 27th, 1898. On Nov. 7th, 1901, I saw him in the electrical department at St. Thomas's Hospital. He told me that for over a year after he left the hospital he had had massage and passive movements for "some time" each day. The contraction very gradually improved and he could extend the fingers slightly at first and more so as time advanced; there was now no contraction; the fingers were held in the position of semi-flexion, but the movement of extension was perfectly good. The wrist movements were normal. The forearm was slightly smaller and shorter than on the opposite side and the muscles seemed to be firm to the touch. The power was not quite so good as on the opposite side. Sensation was absolutely normal. The electrical reactions which I took myself were normal, both nerves and muscles. The circulation

in the hand was good and the skin was quite normal. The patient worked now as a watchman and could do his work, or any other, perfectly well.

CASE 3.—A child, aged five years, was admitted to St. Thomas's Hospital on June 25th, 1898, under the care of Mr. Pitts. On April 20th, 1898, he had fallen down and fractured his right arm. When seen in the casualty department of the above hospital it was found that there was a greenstick fracture of the right ulna and radius at the junction of the middle and upper thirds. This was set and put up on anterior and posterior splints. He was seen again in a week (April 27th), when the splints were removed and the arm appeared to be progressing satisfactorily; the splints were re-applied, and the patient was seen again on May 3rd, when the arm was in good condition and the splints were again re-applied until May 9th. During this last week the boy's mother noticed the fingers to be slightly swollen. On removal of the splints a sore was found on the flexor surface of the forearm; this was dressed and the splints were re-applied. On May 25th the wound was almost healed, but the fingers were flexed and the wrist was slightly contracted. Passive movements, massage, and the galvanic battery were given every other day, but the contraction did not improve. On admission into the hospital he seemed to be a healthy-looking boy with contraction of the hand. The wrist was partially flexed, and the fingers—i.e., the two terminal phalanges—were strongly flexed and could only be extended on full flexion of the wrist. The wrist and fingers could not be extended at one and the same time. There was no loss of power of extension of the wrist. The electrical reactions were normal. The treatment adopted was massage twice daily. On August 15th there was considerable improvement in the affected arm; the tendons were not so tense and the wrist-joint was moved with more freedom. The patient left the hospital on August 6th, 1898. At my request the child came to see me in the electrical department on Nov. 14th, 1901. Over three years had elapsed since the accident. There was now absolutely no deformity of the hand and the position of the fingers was normal. There were very slight weakness and wasting of the forearm muscles, which were firm and hard. The scar of the old pressure sore was a prominent landmark about the middle of the forearm. Sensation was normal and the electrical reactions were also normal. The mother, to whom the recovery was chiefly due, told me that she had persistently, and right up to the time of my seeing the patient, carefully rubbed his arm night and morning. He had also been taught to manipulate the mangle and, as soon as he could do so, to wring out washing; in fact, every movement that was of any service was employed. The boy was taught to bend his fingers backwards whenever he could, and it was done for him every night and morning after the massage. The deformity very gradually disappeared—in fact, it was only during the last three months—i.e., since August, 1901—that there had been noticed complete absence of any deformity. The patient was now able to do ordinary work as well as any one of his own age.

CASE 4.—The patient, a child, aged four years, was an out-patient at St. Thomas's Hospital. On Dec. 6th, 1900, she had broken her right upper arm just above the elbow. There was a good deal of swelling at the time. She came to the casualty department, where the arm was put up in a flexed position in plaster splints. On the next day the fingers were swollen and were, according to the child's mother, dark in colour, but this fact was absolutely disregarded by the parents.

The patient was not brought to the hospital till the fourth day after the application of the splints. There had been no pain and I suppose that this must have been the reason for such delay. When the splints were removed there was found a large pressure sore on the flexor surface of the forearm at the upper part and contraction of the fingers had commenced. The arm was dressed and only lightly bandaged. On Jan. 17th, 1901, I saw her in the electrical department at St. Thomas's Hospital, where she has continued ever since under the care of Dr. Turney. At that time the following notes of her condition were taken: "The elbow-joint is fixed and in a semi-flexed position. The forearm is held pronated and the muscles are much wasted and seem very firm to the touch. There is strong contraction of the second and third phalanges

FIG. 2.



Condition of hand in Case 4 on Jan. 17th, 1901.

into the palm of the hand with extension of the first phalanges. The wrist is semi-flexed and the fingers cannot be extended except on full flexion of the wrist. The wrist and fingers cannot be extended at one and the same time. The action of the interossei is fairly good. The hand is cold and sensation is normal. There is a scar on the ulnar side of the forearm on the flexor aspect at its upper part showing the site of the past pressure sore. The electrical reactions are absolutely normal except in those muscles supplied by the ulnar nerve in the forearm and hand, which show diminished faradic and galvanic irritability. The nerve also shows diminished reaction to the faradic current. The finger-joints are unaffected. There is well-marked thickening of the internal and lower end of the humerus, and this, I think, limits movements of the forearm on the arm. Dr. Turney examined the case and diagnosed it as ischæmic myositis; he also found the electrical

reactions as above. Massage was ordered by Dr. Turney and was carried out three days a week, for 15 minutes at each visit, by a competent nurse, the mother doing the massage as directed in the intervals of her visit to the hospital. The condition has shown some improvement, but the contraction is quite typical. It is now 10 months after the accident, and both flexion and extension of the forearm can be well carried out, also pronation and supination, but to a much less degree. The hand is still in the same position, but the movement of the fingers is better. Passive extension of the fingers causes the child a good deal of pain, but not nearly so much as it did. Sensation is normal. Skin normal. No trophic lesions. Electrical reactions quite normal even in the ulnar distribution, so it is likely that the partial loss before was due to splint pressure. The circumference of the forearm is markedly diminished as compared with the sound side, and there is obvious shortening. Treatment is carried out exactly the same as before."

The illustration (Fig. 2), for which I am indebted to Mr. Grimwade, shows the absolutely typical condition of the contraction. I know also of three other cases, but these I am unable to record owing to the fact that I cannot obtain full notes of them.

The following is a brief account of all the cases the literature of which I have been able to obtain.

CASE 5.—A boy, aged eight years, came under the care of Mr. Raymond Johnson with extreme contraction of the wrist and fingers following fracture of the lower extremity of the humerus.¹ The case had been treated by means of wooden splints which, as a result of undue pressure, had produced a sore on the front of the arm. The length of time between the fracture and the subsequent deformity of the wrist and fingers was not stated. Some slight degree of contractility still remained in the affected muscles—i.e., the flexors of the fingers. An exploratory operation had shown that there was no abnormal condition of the nerves at the seat of the fracture. A diagnosis was therefore made of Volkmann's "ischæmic paralysis." In order to relax the contracted tendons a short piece of bone was excised from the middle of the shaft of the radius of the ulna. The effect on the contracted wrist and fingers was satisfactory, but, unfortunately, the divided bones were repaired only by fibrous tissue and a leather splint was necessary to give strength to the arm.

At the discussion at the meeting of the Harveian Society after the reading of this case Mr. Edmund Owen said that he had met with three cases of this sort, all in children. He described one in which the forearm had been fractured in its upper part with subsequent ischæmic myositis. He had cut down on the median nerve and had found it healthy, but the flexor muscles were in a state of fibrous degeneration. Division of the contracted tendons had produced an unsatisfactory result.

CASE 6.—A girl, aged six years, was admitted to Guy's Hospital under the care of the late Mr. J. N. C. Davies-Colley³ on May 18th,

1898. The child had fallen out of a cart and had broken her right arm in 1896. The medical man who attended the case is reported to have said that there were three fractures about the elbow-joint and that the humerus was split longitudinally to about the middle of the shaft where there was a transverse fracture. The arm was set and it got quite well except for a lump which formed just above the elbow and prevented the child flexing her arm. This lump, together with a ridge which formed along the line of the splint, was removed by Mr. Pollock on the December after the accident with a good result. The power of flexion of the forearm returned (Owing to the death of Mr. Pollock the case came under the care of Mr. Davies-Colley.) The condition of the patient was reported to be as follows: "Elbow very prominent, otherwise normal; wrist is flexed at a right angle; metacarpophalangeal joints are extended; the inter-phalangeal joints are flexed. Extension of forearm is perfect, while there is no power to extend the wrist, and very slight power to extend the phalangeal joints. The forearm is pronated with great limitation of pronation and supination. Sensation normal. Slightly above the level of the elbow-joint is a T-shaped scar, and on pressure in this area a few small tender nodules are felt. The flexor muscles of the forearm are wasted and hard. There is no evidence of any nerve palsy. There has been a pressure sore in this case, which is shown now by induration of the skin and muscles, which are wasted." The treatment adopted was as follows. A three-inch incision was made in front of the forearm, just below the elbow-joint. The muscles, which were much wasted and were formed chiefly of fibrous tissue, which was also intimately connected with the median and ulnar nerves, which were rather swollen, were otherwise healthy. The affected muscles—viz., the flexor sublimis, flexor carpi ulnaris, palmaris longus, flexor carpi radialis, pronator teres, and the flexor profundus—were partly cut and partly torn through. Vigorous efforts were made to straighten the wrists and fingers, which succeeded as regards the wrist but not the fingers. The result of the operation was perfect extension of the wrist, but all attempts to extend the fingers were useless. One month after the first operation a second was performed. An incision was made just above the wrist line; the tendons of the flexor sublimis, flexor profundus, and the flexor longus pollicis were cut through; the fingers and thumb were completely relaxed. The arm and hand were put in position on a splint with the fingers and wrist fully extended. Three months after this operation the fingers were in a good position and had good movement except for flexion, which was, of course, absent.

Mr. Davies-Colley, in the same paper, also narrates a case of myositis in the calf muscles, that of a boy with very bad talipes equinus, so that the toes were pulled down so much that they looked like "claws." Two years previously he had sustained a compound fracture of the tibia and fibula, the calf muscles being injured. The parts healed after long suppuration. Mr. Davies-Colley had divided the tendo Achillis, all the tendons behind the malleoli and the flexor longus hallucis, so that the boy had his toes and foot in good position.

CASE 7.—A boy, aged six years, who was sent to Mr. J. Jackson Clarke,⁴ gave the following history. Six weeks previously he had sustained a

fracture of the lower end of the humerus, which had been put in splints and had re-set three days later. There had been much swelling of the elbow joint and for the first two or three weeks the boy screamed if his fingers were touched and was incapable of moving them. The swelling about the joint subsided in five weeks, but left it immobile from adhesions, which were afterwards broken down under chloroform. When Mr. Clarke first examined the patient there was no reaction in any of the muscles of the forearm to either the galvanic or faradic current, but after a week's treatment with galvanism and massage slight reaction was noticed, which was followed by some reaction in some of the flexors of the wrist, but the flexor sublimis digitorum, pronator teres, and pronator quadratus never reacted at all, but the supinator longus always reacted. Sensation returned coincidently with the partial return of muscular reaction. Under this treatment the boy got back considerable power in the forearm, but the thumb muscles were very obstinate. For some weeks he had fair use of the arm and hand, but the whole arm then began to waste, stiffen, and become much more pronated. Sensation was perfect. Clawing of the hand began four months after the original accident, and it increased in spite of massage. As soon as the deformity had ceased to increase Mr. Clarke divided the flexor tendons above the wrist. This operation removed the whole deformity.

CASE 8.—A boy, aged four and a half years, was admitted into St. Mary's Hospital on Nov. 5th, 1898, under the care of Mr. H. W. Page.⁵ In the preceding month he had fallen on his left elbow and had sustained a transverse fracture of the humerus. (Separation of the lower epiphysis was not excluded.) The treatment adopted at the time of the accident was anterior and posterior splints to the forearm, with the limb put up in a flexed position. All seemed well the next day, but when the child was brought to the casualty-room a few days later there was found to be total loss of power in the fingers and wrist. There was a superficial slough immediately below the bend of the elbow caused by splint pressure; this became detached in about four weeks, and left an open wound which healed by granulation. The treatment employed at the second visit to the hospital was a single posterior splint, which was, however, abandoned at the end of four weeks, and the parents were instructed to manipulate and rub the arm, for an increasing tendency to contraction of the fingers had been noticed, and the wrist was also becoming more and more flexed. The attempt at reduction under an anæsthetic was fruitless. Mr. Page first saw the patient three months after the accident; the child's arm was then described as follows: "It is flexed and in a position midway between pronation and supination. There is extreme flexion of the wrist and the fingers are flexed on to the palm. The old scar is tender, so is the forearm. The joints are clearly unaffected. Extension of wrist and finger is hardly possible even with force. There is partial anæsthesia, only involving the ulnar distribution of the hand, and some wasting of the first dorsal interosseous muscle. The flexor muscles seem firmer than usual. No injury can be detected to the median, musculospiral, or ulnar nerves, except that previously mentioned. My own belief is that there had been a separation of the lower epiphysis of the humerus. Contraction is not lessened under an anæsthetic." Massage, electricity, and passive movement were all found to be useless. On Dec. 20th, 1898, Mr. Page operated. An incision was made just above the wrist line, and the tendons were lengthened in the usual way. The muscles gave the impression of being stiff and unyielding, firmer than natural, and as if

their structure had been changed. The hand and arm were secured after the operation in the flexed position. The parts healed by first intention. At the end of 14 days gradual passive movements of the forearm, the hand, and the fingers took place. Massage and electricity were added. The patient left the hospital in February, 1899, with very slow improvement. He then attended the out-patient department for electrical treatment, under the care of Dr. Wilfred J. Harris, who stated that there was at first very decided reaction of degeneration in the affected muscles; recently the condition was not so marked. In July, 1899, Mr. Page next saw the child. There was now distinct improvement. The forefinger tendons had not united, otherwise all had. By October, 1899, great progress had taken place. All the tenderness had gone, the forearm could be completely extended, and the wrist and the hand could be voluntarily put in the extended position. Flexion of the fingers was easily performed and the child could "make a fist." In the forefinger the flexor profundus alone acted upon it. The muscles of the forearm had lost that peculiar sense of resistance so characteristic of them.

CASE 9.—A girl, aged eight years, was admitted into the Leeds Infirmary under the care of Mr. H. Littlewood⁶ on Nov. 17th, 1898. Four months before admission she had a fracture separation of the lower end of the humerus, with a good deal of swelling of the parts. The arm was put up in an internal rectangular splint for five weeks. When the splint was removed it was noticed that the fingers were contracted and the contraction gradually increased. There was some limitation of the movements of the elbow-joint; it could be flexed to about a right angle, but could not be completely extended; flexion was limited by a bony prominence at the inner side of the lower end of the humerus. Extension of fingers was impossible except when the wrist was flexed and then it could be easily accomplished, otherwise the fingers were contracted into the palm of the hand. There was no sign of any past pressure sore. There was a lump in the upper third of the forearm on the flexor aspect, situated in the muscles. There was some loss of sensation in the ring finger and in the little finger. An operation was performed on Dec. 5th. All the flexor tendons were lengthened about an inch; the fingers and wrist were extended. A firm thick pad of antiseptic wool was applied from the finger tips to the elbow. The wound healed by first intention. After leaving off the dressing for a few days it was found that there was a tendency to contraction of the sutured tendons. To prevent this the limb was massaged and a back splint was worn for two or three hours every day. The patient's condition so improved before leaving the infirmary that she could do some knitting. The parents had persevered with the rubbing and the child had a very useful hand as the result.

CASE 10.—A girl, aged six years, was admitted under the care of Mr. Littlewood⁷ into the Leeds Infirmary on Jan. 7th, 1899. In May, 1898, she had fallen from a ladder and had sustained a severe fracture about the left elbow-joint, also of both bones of the forearm. There was considerable swelling of the parts and the fractures were with difficulty kept in position. A splint sore formed about the middle of the back of the forearm. Contraction of the fingers was very marked so that in flexion of the wrist the fingers could not be fully extended. Eight months had elapsed since the time of the accident. Both fractures had united and movement of the elbow-joint was good. A lump in the flexor muscles of the forearm was well marked. The operation was performed on Jan. 9th, 1899. All the tendons except the flexor carpal ulnaris were divided, lengthened about an inch, and sutured. Similar dressings were used as in Case 9. The wound healed by first intention.

Daily massage was employed and the patient left the infirmary on March 14th, 1899. The fingers were then quite straight and she had some power of flexion. When the ease was reported the condition of the implicated parts was greatly improved and the attainment of a very good result appeared probable. On exposing the nerves they were found to be healthy, in both this case and in the preceding case (Case 9).

CASE 11.—A girl, aged three years, was admitted into the Metropolitan Hospital on May 2nd, 1900, under the care of Mr. H. L. Barnard,⁸ with the following history. On March 16th, 1900, she broke both bones of the right forearm about the middle; anterior and posterior splints were applied. She was seen on the next day; there was no pain. When the splints were readjusted at the end of the week a pressure sore was found extending about three inches from the middle of the front of the forearm to the front of the wrist, whilst a smaller sore was found at the back of the forearm in its lower part, and a still smaller one upon the thenar eminence. The sores rapidly healed, as did the fracture also. No note was taken at the time whether the child moved her fingers or not. About the middle of April the fingers and the top joint of the thumb began slowly to flex, and this flexion steadily progressed in spite of massage and the restraint of a splint. The position of the hand on admission into the hospital was that of *main-en-griffe*. When the wrist was extended the fingers were extended at the metacarpophalangeal joints and flexed at the interphalangeal joints. The last phalanx of the thumb was fully flexed. When the wrist was completely flexed the fingers could be extended. There was no definite anaesthesia. Voluntary movements of the hand and the wrist were practically lost. On June 27th a chronic whitlow was seen on the tip of the right index finger. On Dec. 10th Mr. Barnard operated. The four tendons of the flexor sublimis, the tendon of the flexor longus pollicis, and six strands of the flexor profundus were lengthened in the usual way and the tendons were sutured. Although no tourniquet was applied there was very little bleeding; the wound was very dry. The muscles exposed were pale, firm, fibrous, and dry, very unlike the muscles of children. The arm was put on a splint with the fingers fully extended. The wound healed by first intention. The after-treatment adopted was massage and passive movements every other day. They were begun 14 days after the operation. The child wore a back-splint at night, as there were signs of further contraction. During the day the sound arm was tied to the side so as to give the injured arm plenty of movements when the child was playing with her toys.

CASE 12.—A little boy, aged four years, was admitted into the Metropolitan Hospital on May 12th, 1900, under the care of Mr. Barnard.⁹ On March 15th the patient had crushed the upper part of his left forearm, producing extensive swelling from effusion of blood; fracture was excluded by the x rays. The arm was placed on an external angular splint and was only lightly bandaged as it was very painful. About five weeks later contraction of all the flexor tendons commenced, and when seen by Mr. Barnard his hand was in the condition of *main-en-griffe*. The usual wrist sign was present. The forearm was fully pronated and fixed. There was no definite anaesthesia of the hand, although the skin of the digits was smooth and glossy and the whole hand was much colder than its fellow. Patient and persistent massage and passive movements all produced no improvement—in fact, the contraction increased. On May 30th Mr. Barnard operated, splitting the tendons of the flexor sublimis, the flexor profundus, and the flexor longus pollicis as before and then suturing

them. Absence of hæmorrhage and dryness of the wound were nearly as marked as in Case 11. The parts healed by first intention. The same treatment was adopted as was used in the last case. A ehronic, painless whitlow appeared on the index finger. Improvement was very marked after four months' treatment. As the hand was still pronated Mr. Barnard operated again on Oct. 20th. The pronator quadratus was separated from its ulnar attachment, then the forearm was readily supinated and fixed in this position on a splint. The after-treatment consisted of a splint at night, passive movements, and massage every day. There was very fair rotation of the forearm. In this case and in Case 11 the patients were progressing favourably at the time that this paper was written. The electrical reactions of the muscles of the forearm in this case were made by Dr. W. S. Hedley lately, who stated that he obtained a reaction of degeneration.

CASE 13.—The patient, a female, aged 20 years, came under the care of Mr. F. C. Wallis,¹⁰ at Charing Cross Hospital in July, 1900, with the rare deformity of congenital absence of the superior radio-ulnar articulation in both forearms. The right forearm was capable of some degree of supination, but in the left it was impossible to obtain any such movement. In consequence the girl was unable to earn her living. Mr. Wallis operated at the earnest desire of the patient and her friends on July 6th, 1900. The operation took one and a quarter hours, and during this time an Esmarch's bandage was kept round the upper arm. The radius was divided close to the head and the arm was forcibly supinated; in doing this the ulna was fractured in its lower third. The wound was closed and the arm was fixed in splints. 24 hours later the arm, which was much swollen, was red and covered in places with large bullæ. Paralysis and loss of sensation seemed complete and the general temperature was raised. The splints were immediately removed and some stitches were taken out to relieve tension and the arm was redressed. There was no suppuration, gradually the swelling diminished, but the paralysis continued, and the fingers assumed the position of *main-en-griffe*. 10 days after the operation it was found that the anæsthesia of the forearm and hand was confined chiefly to the ulnar and median distribution. Passive movements were now daily performed and galvanism was applied, but the ends of the fractured ulna were unable to unite owing to these movements. Three months after the operation Mr. Wallis wired the fractured bone with good result. The condition of the hand and forearm after the ulna had united was reported to be as follows: "With the wrist extended the second and third phalanges are flexed on the palm; with the wrist flexed the fingers can be extended; the thumb is practically useless and the muscles of the hand are much wasted. Loss of sensation as before." For the next seven months the hand and forearm were daily galvanised and faradised, and a hot-air bath was used. Massage was daily performed and on three separate occasions the wrist and fingers were manipulated under gas. This treatment at first gave good results; the muscles of the upper part of the forearm improved, the fingers could be easily extended, and a certain amount of active movement was restored to the fingers and thumb. The wrist was more pliable and sensation was much improved. The skin was normal. This was the condition of the patient's arm nearly 12 months after the original operation. A second operation was now performed. The tendons of the flexor sublimis, the flexor profundus, and the flexor carpi radialis were divided and lengthened in the usual way. The tendon sheaths on being opened were found to be much thickened and more vascular than usual. The median nerve was found to be surrounded by fibrous tissue, which was adherent to the nerve sheath. The muscles exposed

were pale in colour and their fibres were to a great extent replaced by fibrous tissue. The wound was closed and the hand was placed on a back splint with the fingers extended. Passive movements were commenced at the end of a fortnight and active movements in the middle of the third week. Galvanism and massage were also applied. The report proceeds: "The present condition of the hand is one of improvement. Sensation has completely returned over the distribution of the radial nerve, and partially over the median, but the ulnar shows little progress. After massage the fingers are quite supple and the range of movement is much increased. She can also use the hand extremely well for needle-work."

CASE 14.—A youth, aged 18 years, was shown by Professor Sehloffer¹¹ at the Association of German doctors in Prague. The patient was brought to the clinic on Oct. 19th, 1900, having shot himself with a revolver in the region of the heart. The bullet entered at the level of the fifth rib at the midsternum. No exit wound was found and no projectile could be felt under the skin. The patient was collapsed. On examination the heart dulness was found to be normal, the right radial pulse could not be felt, and the left was very weak, rate 100. The patient slowly improved in bed in the next four hours, the action of the heart becoming stronger. On the following day there was severe pain in the right arm and the right radial pulse could not be felt; the left pulse was good and fairly strong; the movement of the right elbow-joint was normal and the right hand and finger-joints were immovable except for a slight amount of extension of the hand. The muscles of the right forearm were swollen, hard, and very tender on pressure. The skin of the forearm and hand was cyanotic. Passive movement of the fingers caused severe pain in the forearm. Sensation was intact in the upper arm, but was very much diminished below the elbow-joint, in the region of the median, ulnar, and musculo-spiral nerves. Professor Sehloffer diagnosed ischæmic paralysis. On examining for the projectile in the depths of the right axilla, in the region of the axillary artery there was a hard sense of resistance which was thought to be the projectile, and this was confirmed by the Roentgen rays. This had produced closure of the axillary artery, probably from thrombosis, and had led to such an extraordinarily rare result as ischæmic paralysis. A little later there was dulness at the base of the right lung behind, with a temperature of 39.5°C.; both these signs finally disappeared. The local condition improved greatly under very energetic massage, so that the power of movement greatly returned; but at the time that the case was reported the right forearm was markedly atrophic when compared with the left side. The muscles felt hard and firm; in some places hard nodules could be felt. Dr. Margalie found the reaction of degeneration in the affected muscles. Sensation had, on the whole, become a little better, especially in the forearm, but in the hand it was still diminished to all three nerves, and in the fingers sensation was almost absent. The treatment adopted had been hot-air baths, but these caused severe blisters on the third and fourth fingers without the patient being aware of the fact. No effort was made to remove the bullet. Professor Friedel Piek, in the discussion which followed, remarked that this case was noteworthy owing to the change in sensation, for judging from the literature the rule in ischæmic paralysis was that motor paralysis lasted for a long time, but sensation was rapidly recovered.

CASE 15.—The patient, a boy, aged 12 years, was admitted to St. Thomas's Hospital under the care of Mr. W. H. Battle¹² on Dec. 2nd, 1895, and remained under treatment until Feb. 14th, 1896; since then he

TABLE I.—CASES PUBLISHED FOR THE FIRST TIME.

Cases.	Under the care of—	Nature of the accident.	Treatment adopted.	Remarks.
Case 1	Mr. Clutton and Dr. Turney.	Fracture of the right arm just above the elbow-joint.	Splints, anterior and posterior.	A good deal of swelling of the soft parts and pressure sore
Case 2	Mr. Pitts and Dr. Turney.	Some injury, cause uncertain.	Anterior splint to the forearm for five weeks; plaster-of-Paris for two months.	Well-marked swelling of the soft parts. No pressure sore.
Case 3	Mr. Pitts and Dr. Turney.	Greenstick fracture of the right radius and ulna at the junction of the middle and upper thirds.	Anterior and posterior splints.	Pressure sore on flexion on the surface of the forearm.
Case 4	Mr. Clutton and Dr. Turney.	Fracture of the lower end of the right humerus.	Plaster splints.	Well-marked swelling of the soft parts; pressure sore.

TABLE II.—CASES FROM THE LITERATURE OF THE SUBJECT.

Cases.	Under the care of—	Nature of the accident.	Treatment adopted.	Remarks.
Case 5	Mr. Raymond Johnson.	Fracture of the lower end of the humerus.	Wooden splints.	No statement as to whether any swelling was present; pressure sore on the front part of the forearm.
Case 6	Mr. Davies-Colley.	Severe fracture of bones "about the elbow-joint."	Not stated.	Considerable swelling of the soft parts and a pressure sore.
Case 7	Mr. Jackson Clarke.	Fracture of the lower end of the humerus.	Splints.	Much swelling of the elbow-joint.
Case 8	Mr. Pigo.	Transverse fracture of the lower end of the humerus; separation of the lower epiphysis.	Anterior and posterior splints to the forearm (limb put up in flexed position).	Pressure sore; presence of swelling of the soft parts, but stated.
Case 9	Mr. Littlewood.	Fracture separation of the lower end of the humerus.	Internal rectangular splint.	Marked swelling of the tissues; no pressure sore.
Case 10	Mr. Littlewood.	Severe fracture of the lower end of the humerus, radius, and ulna.	Splint (kind of splint used not stated).	Considerable swelling of the soft parts; pressure sore.
Case 11	Mr. Barnard	Fracture of the radius and ulna (about the middle of the shaft).	Anterior and posterior splints.	Large pressure sore on the forearm and two others of smaller size; presence of swelling not stated.
Case 12	Mr. Barnard	Severe contusion of the upper part of the forearm; fracture excluded by the x rays.	External angular splint and very light bandaging.	Great swelling of the soft parts with bloody effusion; no pressure sore.
Case 13	Mr. F. C. Wallis.	Esmarch's bandage to the upper arm for one and a quarter hours.	—	Much swelling and redness and the arm covered with bullae.
Case 14	Professor Schloffer.	Thrombosis of the right axillary artery.	—	The skin of the right forearm and hand swollen and slightly cyanotic; the muscles very tender.
Case 15	Mr. Battle.	Fracture of the forearm.	Anterior and posterior splints.	Pressure sore.
Case 16*	Mr. Davies-Colley.	Compound fracture of the tibia and fibula; calf muscles injured.	—	Prolonged suppuration.
Case 17*	Mr. Edmund Owen.	Fracture of the upper part of the forearm.	—	—

* No details of these cases are given in the present paper.



has been in the out-patient department till June of this year. The history of the case is as follows. The boy broke his forearm on May 21st, 1895. Six weeks after the fracture he could not put his fingers straight. The fracture had been treated by means of anterior and posterior splints which had produced a pressure sore in the middle of the forearm under the anterior splint. The left arm was wasted and the forearm was held pronated with the fingers flexed. When the wrist was flexed the fingers could be extended; this, however, could not take place with the wrist extended. There was marked wasting of the hand muscles. A scar was present over the front of the forearm, showing the site of the past pressure sore. Sensation was normal. The electrical reactions were normal. No lengthening of the flexors could be brought about under an anæsthetic. The muscles were very rigid. The treatment adopted was rubbing, galvanic current, and gymnastic exercise, and there was some improvement.

Definition.—A contraction of the fingers and sometimes of the wrist which comes on rapidly with loss of power which is not absolute in the forearm muscles after a severe injury, usually in the region of the elbow-joint, generally in young children. The deformity is due to changes in the flexor muscles without injury to the peripheral nerves caused in many cases by tight bandaging and the pressure of splints.

I next come to discuss the deformity from its different standpoints.

Etiology.—By the following tables (Tables I. and II.) which I have made of my own cases and of those of the literature the chief causative influences can be seen at a glance.

In Table II. pressure sore occurred in six out of a possible 11 cases. In one of the six cases there were three pressure sores; of the remaining five cases it did not occur in three, in one it is not stated whether it did or did not, and in the last case bullæ were present instead. In Table I., out of four cases pressure sore occurred in three and was absent in one. From this it is easy to see how common a factor it is. I do not think it causes the contracture, for it is generally limited to one part of the forearm, not over an extensive area, nor does it usually extend down deeply into the soft tissues; therefore it is hard to understand why it should cause such contraction of all the forearm muscles; but I do think it is a sign of great importance, as it does show to what pressure the parts have been subjected. There is usually a good deal of swelling, which has been treated by tight bandaging and splints; with such great resistance the skin is nearly bound to slough. The late Mr. Davies-Colley,¹³ on the other hand, believed that "pressure sore" was a cause of the contracture, but it is obvious if it is in some

cases that it cannot be in all. Splint pressure is claimed by many as the "cause." Mr. Littlewood¹⁴ disagrees with this statement and his argument is backed up by the fact that it is clearly shown by looking at Table II. that there was no splint pressure in certainly *three* cases out of the 11, and possibly more. It is far more likely that it is a combination of large effusion into the soft parts and splint pressure, but that it does occur without any splint pressure I have already stated. Mr. Page thinks that the contracture is caused by a combination of pressure, fixation, and ischæmia. Other causes are Esmarch's bandage (Case 13 shows this fact very well and Volkmann¹⁵ states: "I have never seen a case result from the use of Esmarch's bandage although it is known to be a cause"); when the main artery of a limb has been ruptured, ligatured, or contused; and lastly, the very interesting case (Case 14) published by Professor Schloffer, where it followed thrombosis of the axillary artery; long-continued and severe cold;¹⁶ rupture and severe contusion of the flexor muscles in young children (this fact will be dealt with in the pathology); the suppurative of muscles; and finally, Mr. Anderson summarises the etiology thus: "It is a result of prolonged fixation of forearm fractures by any form of apparatus that intercepts the free circulation of blood through the muscles and nerves of the part."

Symptoms.—These come on rapidly, as Volkmann describes, "in half a day or less in very severe cases." The great feature in the history of a case of this deformity is the onset of paralysis of a limb with contracture; this is most important and characteristic. The fingers sometimes go blackish in colour and frequently swell. There is rarely any pain; the absence of this symptom may be the cause of the splints not being loosened more rapidly, but on removal of the splints the forearm is often tender and sometimes extremely so. There is often sloughing of the skin, usually in the middle or upper part of the flexor surface of the forearm. The fingers are at first simply flexed, but soon pass into the position so characteristic of this deformity, which has been so ably described by Mr. Littlewood. Once this position is seen it is not easily forgotten; it has been present in every well-marked case. With the wrist extended the metacarpophalangeal joints are extended also; the inter-phalangeal joints of the fingers and the terminal joint of the thumb are, however, strongly flexed, so that the tips of the fingers touch

the lower part of the palm, and no reasonable amount of force seems capable of straightening them; but as soon as the wrist-joint is flexed to a right angle then the inter-phalangeal joints can be easily extended. In very bad cases the wrist becomes strongly flexed and is incapable of extension. The hand is pronated and the forearm is generally semi-flexed. The flexor muscles of the forearm seem hard, firm, and much wasted. A thickening is sometimes felt in the soft tissues, usually in relation to the pressure sore which is so frequently present. A swelling, bony in character, is sometimes to be found at the lower end of the humerus, generally at the inner side. Sensation may be normal, or there may be partial or complete anæsthesia; this is dependent on the condition of the peripheral nerves. There are thus to be seen usually three grades of this deformity: (1) partial contraction of the fingers; (2) the hand in the typical position; and (3) strong flexion of the wrist and fingers, without any power of extension. There are no true trophic lesions in pure ischæmic myositis, but the hands are frequently cold and blue and the skin smooth. The fingers frequently swell when the arm hangs down by the side for some time. It is said that the joints become ankylosed, similar to the ankylosis in traumatic arthritis, but I could find no such case in the literature or any mention of such a condition having been recorded; in those cases in which any reference was made to the joints they were always said to be normal. In well-marked cases there is as much shortening of the bones as is met with in acute anterior poliomyelitis, &c. How does this occur? Dr. Turney's explanation seems completely to explain such a result. He says: "The growth of bones proceeds only *pari passu* with the amount of support, it has to give to its attached muscles."

Electrical reaction.—Dr. Turney tells me that he considers the normal electrical reactions of both muscles and nerves to be the most diagnostic feature of this deformity. It was present in all my cases, and in one case in Table II. the reactions were taken by Dr. Turney and also by myself. There is no mention of the electrical reactions in the different books on medical electricity except by Dr. Hedley who says: "It is stated that the electrical reactions are not altered." On the other hand, when one refers to the recorded cases composing Table II. the exact opposite is found in four of those that were examined; out of the 11 recorded these

showed reaction of degeneration, in the fifth case the reaction was normal. Dr. Harris, who examined Mr. Page's case, says: "Any ischæmic condition would, I imagine, damage the nerve end-plates as well as the muscles, and one might expect, I should think, some reaction of degeneration." He also mentions the fact that in acute myositis there are no electrical changes until in the late stages, when atrophy, if any, sets in. Dr. Hedley, who examined the muscles of the forearm in Case 12, reported that he obtained reaction of degeneration. Professor Erb states that in a primary muscular condition the electrical reactions are normal. It is possible, however, that he had not examined cases of ischæmic myositis. There are several points against the presence of the reaction of degeneration. 1. One cannot be certain that the nerves were unaffected in those cases in which reaction of degeneration was obtained. 2. If reaction of degeneration was present then we conclude that those muscles are practically paralysed for the time being, and whether this is due to the main nerve trunks being affected or to the motor end-plates makes no difference from a diagnostic point of view. Now, how is it that when the paralysed muscles had their tendons lengthened they could perform the movements of normal muscles, as they did in Mr. Page's case, and also seem to have done in Mr. Barnard's case? This is surely peculiar for paralysed muscles to act normally because their tendons are lengthened. It may be that the muscle recovered from the reaction of degeneration, but no absolute statement to that effect is made, and if the nerve end-plates are damaged by the changes in the muscles, as Dr. Harris suggests, it seems quite unlikely that much improvement will ever take place when one considers the fibrous tissue which has taken the place of the muscle fibres. The peripheral nerves are no doubt affected in some of the cases, as in two cases in Table II. the nerves—i.e., ulnar and median—were cut down on and examined were found to be surrounded by fibrous tissue which was adherent to the nerve sheath, and in one case the nerves were rather swollen. In Case 14, although it is not stated, it seems to me that the ulnar and median nerves were seriously injured. A point of particular importance is that the muscular branch of the nerve may be injured in some cases and may cause the reaction of degeneration, while, of course, it is quite possible that these might recover and, in fact, are far more likely to do so than the motor end-plates, which to my mind, for reasons already stated, if they are once injured, must be so for ever.

Lastly, what do we know at the present day of the motor end-plates, more especially their relation to electrical reaction ?

Pathology.—I will simply state here the opinion of the different observers and commence by giving that of the eminent German surgeon who first described the disease. Volkmann considers that the paralysis and contracture are dependent on the diminution of arterial blood to the muscles—i.e., are ischæmic in origin—(see Case 14) whilst the simultaneous venous congestion which often takes place hastens the onset of the paralysis ; the muscle fibres, being deprived of their oxygen for some time, perish ; and the contractile substance coagulates, breaks up, and disappears—that is to say, *rigor mortis*. The rigidity and contracture of the limbs are made worse by the material contracting, which was present for the process of repair. The degree of paralysis and contracture depend on the length of time the circulation of the blood has been arrested. If the anæmia has been very marked the most serious results may happen in 12 hours or less. A slight but prolonged constriction and pressure of a limb may cause symptoms of great severity, especially in fractures of the radius. The late Mr. Davies-Colley¹⁷ believed that this deformity is due to splint pressure on the skin causing inflammation which spreads to the muscles ; or suppuration of all the soft parts may be got, the resulting fibrous tissue which contracts and gives rise to the deformity being formed from the granulation tissue of the soft parts. Mr. Raymond Johnson¹⁸ considers that the “paralysis” is dependent upon inflammation and subsequent fibrous degeneration of the muscles caused by the application of splints sufficiently tightly to interfere seriously with the circulation through the part. Mr. Wallis¹⁹ describes how this deformity of muscle is produced by Esmarch’s bandage : “There is after removal of the bandage excessive capillary hæmorrhage ; it occurs not only in the skin but also in the muscles. There is no actual blood extravasated, but a large quantity of serum, and with it fibrous tissue-forming elements which escape into and around the tissues. Thus the muscular fibres all become infiltrated with fibro-blastic elements, and eventually the healthy contractile muscle becomes largely mixed with fibrous tissue, and according to the amount of this tissue so contraction occurs. Ziegler²⁰ describes a form of myositis due to the extension of inflammation from the skin or elsewhere manifested by infiltration of the perimysium with liquid and accumulation

of round cells into the connective tissue. The muscle fibres often remain intact throughout ; when they also suffer cloudy swelling, fatty degeneration, and coagulation necrosis make their appearance. The deformity has been likened by some writers to congenital hæmatoma of the sterno-mastoid producing wry-neck. Mr. Clutton²¹ says : "Violence is the main cause of tumour of the sterno-mastoid." Dr. Spencer, quoted by Mr. D'Arcy Power,²² proves beyond doubt that the cause of the condition is injury resulting in rupture of the fibres of the sterno-mastoid, with effusion of blood into the connective tissue. In other cases there is no doubt that inflammation alone may cause the tumour of the muscle. But while, on the one hand, contracture is the rule in ischæmic myositis, it is far less common in congenital hæmatoma of the sterno-mastoid. Mr. D'Arcy Power gives 30 cases, traced by Mr. Clutton, himself, and others, of congenital hæmatoma, of which 11 eventually had wry-neck, but in two of these the deformity was very slight ; it will thus be seen that there is a great difference between the injury and its result in the two deformities in question. Kraske²³ has shown that long-continued and severe cold may produce this deformity. Lastly, it seems to me that possibly, as so many of these cases commence as injuries in the region of the elbow-joint, the synovial membrane might be lacerated and the escape of the contained fluid with possibly some blood around the seat of the injury might help, or even entirely produce, this deformity in some cases. While discussing the pathology of this deformity I will add the condition of the muscles when examined by surgeons at operations. There are five reports in all, and every observer agrees that the muscles are wasted, pale, firm, and dry, and that they seem to be chiefly composed of fibrous tissue.

Diagnosis.—The diagnosis is usually easy, but still there are difficulties at times, chiefly in finding out whether the case is purely ischæmic myositis or whether it is this disease together with injuries of the peripheral nerves. In looking through the literature of the subject I find a large number of deformities which have entered into the diagnosis at some time or other. I think it therefore advisable to mention these and their diagnostic features. A case of Volkmann's contracture gives the history of a severe injury usually in the region of the elbow-joint or forearm accompanied by a large amount of swelling of the soft parts. The patient is usually a child (every patient in Table I. and in

Table II. was under the age of 10 years, except in three instances, and two of these could hardly be included, as in one it was due to Esmarch's bandage and in the other to thrombosis of the axillary artery, and therefore they did not present the usual history). Splints have generally been applied and the contracture of the fingers has come on rapidly. This point, Volkmann²⁴ lays great stress on and says: "The paralysis and contracture arise simultaneously, not as in paralysis of nervous origin, where contraction is a later phenomenon and of gradual onset." A child presenting such a history as this and with the deformity of the hand as described in the paragraph on the symptoms, as well as with normal electrical reactions, is diagnostic of Volkmann's contracture.

We must now consider what other conditions produce such a deformity. I find that the following is a list of nerve lesions which are given as offering points of diagnosis: (1) ulnar, median, or muscular spiral paralysis; (2) the contraction after acute anterior poliomyelitis; (3) Little's disease; and (4) functional disease. The peripheral nerve palsies are alone worth considering fully; in the others the diagnosis is so obvious that a brief account is sufficient.

1. In ulnar paralysis the paralysis generally comes on rapidly after wounds of the arm. The fingers cannot be flexed at the first joint or extended at the other joints. Adduction of the thumb is lost and so are most movements of the little finger. Anæsthesia occurs in most cases, corresponding with the inner side of the hand, the little finger, and the inner half of the ring finger. The reaction of degeneration in the wasted ulnar muscles is present, but no reaction to stimulation of the ulnar nerve with the faradic current. After a long period the "claw hand" is developed. There will be no contraction of the wrist. The hypothenar eminence may disappear. The palm is hollow and trophic changes may be present. Therefore the points of diagnosis are many and should not offer much difficulty. In median nerve palsy there is paralysis of pronation beyond the mid-position; the thumb is extended and adducted. The fingers are not contracted. There is little power to flex the wrist. Electrical reactions show reaction of degeneration in the affected muscles. Anæsthesia corresponding to the radial side of the palm, the front of the thumb, the first two fingers and half the third, and in some

cases the back of the last phalanx of the index and middle finger. Trophic lesions may be present. In this palsy it is quite obvious that there is little resemblance to Volkmann's contracture. In musculo-spiral palsy, although there is dropping of the wrist, it is due to paralysis of the extensor muscles, not due to contraction of the flexors, as in Volkmann's contracture. The fingers are frequently in the position pointed out by Sir William Gowers, the first finger being least and the fourth most affected, thus showing a simple gradation. A very large number of the musculo-spiral palsies which come to the electrical department at St. Thomas's Hospital show this feature. The palsy may be bilateral, as it is usually in lead. The involvement of the triceps and supinator longus in some cases, with the well-marked reaction of degeneration in the affected muscles and the loss of sensation which sometimes occurs, is sufficiently characteristic for a correct diagnosis. Although these points are sufficient for diagnosis between the deformity in question and peripheral nerve palsy, yet it is highly probable that the nerves are also affected in some of the cases of Volkmann's contracture. For instance, we see in some of the cases reported loss of sensation corresponding to definite nerve areas, while in others there have been trophic ulcers. The reaction of degeneration in the affected muscles in four cases out of five in which it was examined for in Table II. is very important, while in Table I. in no case was it present. I think therefore that the electrical reactions show quite clearly that there is, on the one hand, pure ischæmic myositis, with normal reaction; and, on the other hand, ischæmic myositis plus peripheral nerve palsy, producing complete or partial reaction of degeneration.

2. The contracture after the acute anterior poliomyelitis. If any history can be obtained of the onset of the case in question it will be practically sufficient for a correct diagnosis, although acute anterior poliomyelitis may follow directly after an accident, such as a fall, but the injury in no way resembles that met with in Volkmann's contracture. Also the far greater frequency of the involvement of the upper extremity (I can find only one case of Volkmann's deformity in the leg), and the reaction of degeneration in the affected muscles. Perhaps the most diagnostic point is the much longer time which contracture takes to develop in this disease.

3. Little's disease which is also known as "congenital

spastic paraplegia." The involvement of the lower extremities and the etiology of the two diseases are sufficient for a diagnosis, which must be obvious to anyone.

4. Functional disease. I saw one case of Volkmann's contracture diagnosed as "functional." No doubt the mistake arose as it generally does : if we see any disease which we cannot diagnose the temptation is to call it functional. The absence of any serious injury, the greater age of the patient, while the hand will possibly be contracted as well as the fingers atypically form the points of diagnosis. The complete reduction of the contracture under an anæsthetic will be proof positive of functional disease. The electrical reactions in each case will be normal. There are a few other cases which are certainly worth recording here. (1) In the case of a patient under the care of the late Mr. William Anderson²⁵ who was bitten in the forearm by an adder the injury was followed by pain and swelling accompanied by a painful contraction of the fingers which lasted nearly three months ; it was ultimately relieved by massage and active and passive movements. In giving the pathology of this condition Mr. Anderson remarks that it was "due to diffuse inflammation of the inter-muscular planes and perimysial connective tissue ; that it may occur as a result of poisoned wounds and other injuries, sometimes leading to a deformity in the fingers, as is met with in ischæmic paralysis." (2) König (quoted by Anderson) describes a case of flexion of the hand and fingers in a newly-born child caused by a tearing of the flexor muscles at the moment of disengagement of the arms in the course of delivery. Lastly, Dr. Turney tells me of a case which he saw in consultation where there was no contraction of the hand and fingers but great wasting of the muscles of the forearm. At first sight, when he saw the case, he thought that it was due to nerve injury, but he found the electrical reaction quite normal and the flexor muscle of the forearm firm and hard. Two scars showing past pressure sores were also present. The reason of the absence of deformity was due to the fact that the patient had always worn a splint reaching to the tip of the fingers.

Prognosis.—Volkmann makes this statement : "The prognosis is bad, especially in cases where the hand and fingers are affected ; here it is practically hopeless. It is better in the lower limbs, for here tenotomy may be practised ; slighter

cases may be improved with massage." In 1891, or about 10 years after Volkmann's paper, Mr. Anderson gave a prognosis absolutely contradictory to Volkmann. He says: "The lesion—i.e., ischæmic myositis—is seldom of a permanent character and the function may generally be restored by systematic active and passive movements with massage and, if necessary, the galvanic current." He gives no cases to substantiate his statement and there is certainly nothing in the literature that I can find so completely to oppose Volkmann's gloomy prognosis. When, however, one refers to the cases which I have published it will be seen that the prognosis given by Mr. Anderson is exactly in accordance with these results. I think that I am right in stating that the patients in Table I., when they left St. Thomas's Hospital with complete deformity of the hand and forearm, were not expected in two or three years to obtain a normal arm, but such is the case. When I received letters replying to my question from two different patients stating that they had completely recovered I could not understand it, but it was quite obvious when I saw the cases. Surgical methods of lengthening tendons, shortening bones, &c., cannot produce with the very best results possible a better condition of affairs than I now publish. Of course, one cannot be absolutely certain that so happy a result would always ensue; but still these are not selected cases, but those which Dr. Turney had seen in the hospital and which had been diagnosed by him as ischæmic myositis. I cannot say whether the fact of having normal electrical reaction—as all the cases I reported had and have—may be such an advantage as to give recovery by simple massage, &c.

Treatment.—In his Hunterian Lecture of 1891 the late Mr. William Anderson stated that "ischæmic paralysis is a reproach to surgery, since a careful observation of the hand and fingers during the use of splints will always give due warning of the danger." The only objection to this statement is when the deformity arises from other causes than bad treatment, as it undoubtedly may do, Mr. Littlewood holds the view that splint pressure has nothing to do with the production of the deformity. This statement is going to the other extreme and is certainly incorrect in many cases. There is no better illustration than Case 4 of my series, where there was a severe injury with a large amount of swelling. "Plaster splints" were applied to the forearm; this was followed in 24 hours by

swelling and duskiuess of the fingers, paralysis, and contracture, with a pressure sore besides. This is one example out of many. Therefore in a severe injury to the bones of the forearm and lower end of the humerus it seems obvious that anterior and posterior splints should not be applied, or at any rate not in these cases when there is much swelling, and several surgeons, notably Mr. Page, disagree with the use of splints. When the contracture has occurred and is of recent origin Volkmann recommends the extension of the muscles under an anæsthetic. This treatment alone has proved to be valueless, and the extension of the muscles is no easy matter; the contracture still continues till it reaches a maximum even under extension. There seem to be two methods of treatment, medical and surgical. The former consists of massage to the forearm twice daily for 10 minutes or more (as long as there is no pain) and passive movements of the fingers. The galvanic current can be given, but I do not think it would make any difference. This treatment must, no doubt, be carried on without any long interim for about two years to have the complete results here shown, as it took quite that time in both my cases to effect complete cure. The results of this treatment have already been discussed and show what great value it has. Massage in each case was performed by the friends and has given as good a result as any professional expert could possibly obtain, and with this advantage for hospital patients especially—it was performed free of charge.

As to surgical treatment and the time of operation, as many of the cases slowly continue to contract for some time after the accident it seems possible that it would be better to delay operation for three or four months. The different operations which have been performed are numerous. Mr. Davies-Colley cut through the flexor muscles of the forearm themselves, and at a second operation, a month after, cut through all the flexor tendons. The deformity is certainly cured by such treatment, but no hope of flexion of the fingers can ever be entertained. Mr. Raymond Johnson excised a short piece of bone from the middle of the shaft of the radius and ulna. The effect on the contracted wrist and fingers was satisfactory, but the divided bones only united by fibrous tissue and the child had to wear a leather splint. This case was shown at a meeting of the Harveian Society of London on March 3rd, 1898. Mr. Edmund Owen who discussed the treatment of such cases

advised resection of bone, but stated that surgeons must be prepared for the result of non-union of the divided bone, but he gave no proof for such a statement. Tendon lengthening, first advised in these cases by Mr. Page,²⁶ has since been carried out by Mr. Littlewood,²⁷ Mr. Barnard,²⁸ and others. It simply consists in splitting longitudinally the flexor tendons of the fingers or cutting them in a Z-shaped fashion, then when full extension has been applied suturing the lengthened ends. The after-treatment consists of keeping the hand and fingers on a splint for about a fortnight, then gradually applying massage, the galvanic current, and finally by active and passive movements of the fingers, hand, and forearm. Lastly, in cases where the presence of a lump situated at the lower end of the humerus after an injury to the bone interferes with flexion and extension of the forearm this bony mass can be excised. This was done in Case 2 by the late Mr. Pollock with excellent results.

In conclusion, my best thanks are due to Dr. Turney for allowing me to use the cases which have been, or are at present, under his care in the electrical department at St. Thomas's Hospital, and also for much valuable advice in the study of this interesting deformity. I have also to thank Mr. Clutton and Mr. Pitts, as the cases which I report had originally been under their care.

St. Thomas's Hospital.

¹ Krankheiten der Bewegungsorgane, 1875, p. 846. ² A case brought forward by Mr. Raymond Johnson at a meeting of the Harveian Society of London on March 3rd, 1893, and reported in THE LANCET of March 12th, 1898, p. 722. ³ Guy's Hospital Gazette, Oct. 5th, 1898. ⁴ Orthopædic Surgery, 1899, p. 49. ⁵ THE LANCET, Jan. 13th, 1900, p. 83. ⁶ THE LANCET, Feb. 3rd, 1900, p. 291. ⁷ Ibid. ⁸ THE LANCET, April 20th, 1901, p. 1138. ⁹ Ibid. ¹⁰ The Practitioner, October, 1901, p. 429. ¹¹ Wiener Klinische Wochenschrift, No. 1, 1901, p. 25. ¹² St. Thomas's Hospital Records, 1896; also Transactions of the Clinical Society of London, vol. xxix., p. 241. ¹³ Loc. cit. ¹⁴ THE LANCET, Feb. 3rd, 1900, p. 291. ¹⁵ Loc. cit. ¹⁶ Kraske: Centralblatt für Chirurgie, 1879, No. 12. ¹⁷ Loc. cit. ¹⁸ Loc. cit. ¹⁹ Loc. cit. ²⁰ Ziegler, p. 306, set 1-8. ²¹ St. Thomas's Hospital Reports, 1888. ²² Wry-neck and Congenital Hematoma of the Sternomastoid, Transactions of the Royal Medical and Chirurgial Society, vol. lxxvi., 1894. ²³ Loc. cit. ²⁴ Centralblatt für Chirurgie, 1881, vol. viii., No. 51. ²⁵ The Deformities of the Fingers and Toes, p. 66. ²⁶ THE LANCET, Jan. 13th, 1900, p. 83. ²⁷ THE LANCET, Feb. 3rd, 1900, p. 291. ²⁸ THE LANCET, April 20th, 1901, p. 1138.

VOLKMANN'S CONTRACTURE.

To the Editors of THE LANCET.

SIRS,—A point of great importance has been omitted from my paper on Volkmann's Contracture owing to a mistake of mine during the correction of the proof-sheets. It is to the effect that Professor Oppenheim of Berlin refers briefly to ischæmic paralysis in his "Text-book of Nervous Diseases," 1900. Here he emphasises the importance of *normal* electrical reactions as the most characteristic feature in the diagnosis of this deformity.

I am, Sirs, yours faithfully,

LEONARD S. DUDGEON.

Jan. 11th, 1902.

